REMARKS

By this paper, claims 37 and 85 have been amended. Claims 37-85 remain pending. Reconsideration of the present application is respectfully requested.

In the outstanding Office action dated August 9, 2005, the disclosure was objected to for failure to cite patent numbers of applications which were identified in the specification and which have since issued. By this paper, the specification has been amended to include such patent numbers. Accordingly, it is believed that the objection to the specification has been traversed.

Additionally, in the outstanding Office action, the Examiner indicated that a document entitled "Heat Treatment of Steel" could not be located and that it would not be considered until a replacement copy was provided. Therefore, Applicants have submitted herewith a replacement copy of the document entitled "Heat Treatment of Steel" and respectfully request that the document be considered in connection with the present application.

Moreover, in the August 9, 2005 Office action, claim 85 was objected to due to lacking a period at the end of the claim. Claim 85 has been amended to include a period to thereby traverse the objection to the claim.

Furthermore, the Examiner set forth four different double patenting rejections in the August 2005 Office action. Claims 56 and 57 were rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 20 and 21 of U.S. Patent No. 6,827,734. Also, claims 37-41, 44-50, 53-59, 62-66, 70-73,

75 and 77-85 were rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-7 of U.S. Patent No. 6,736,843 and claims 56 and 57 were rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claim 1 of U.S. Patent No. 6,419,693. Finally, claims 56 and 57 were again rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1 and 3 of U.S. Patent No. 5,636,641.

In view of the obviousness-type double patenting rejection of claims 37-41, 44-50, 53-59, 62-66, 70-73, 75 and 77-85, Applicants have submitted a Terminal Disclaimer. The Terminal Disclaimer disclaims the terminal part of the statutory term which would extend beyond the expiration date of the full statutory term of U.S. Patent No. 6,736,843. Its believed that submitting such a Terminal Disclaimer operates to traverse the rejection of these claims under the judicially created doctrine of obviousness-type double patenting as set forth in the outstanding Office action.

Turning to the double patenting rejections of claims 56 and 57, it is respectfully submitted that the subject matter recited in claims 56 and 57 is not an obvious variation of the invention defined in claims 20 and 21 of U.S. Patent No. 6,827,734; claim 1 of U.S. Patent No. 6,419,693; or claims 1 and 3 of U.S. Patent No. 5,636,641. Significantly, claims 56 and 57 further limit independent claim 53 which recites a cylindrically shaped balloon-expandable stent comprising a plurality of independently expandable and interconnected cylindrical elements wherein the cylindrical elements have an elasticity insufficient to allow expansion from a first low profile delivery configuration to a second

radially expanded configuration without permanent plastic deformation, the cylindrical elements having an undulating component. Clearly, neither claims 20 and 21 of U.S. Patent No. 6,827,734, nor claim 1 of U.S. Patent No. 6,419,693, nor claims 1 and 3 of U.S. Patent No. 5,636,641 recite cylindrical elements having an elasticity insufficient to allow expansion from a first low profile delivery configuration to a second radially expanded configuration without permanent plastic deformation wherein the cylindrical elements have an undulating component. Such recited subject matter render the pending claims patentably distinct from the claims of these patents. Therefore, it is respectfully requested that the double patenting rejections of claims 56 and 57 be withdrawn.

The Applicants now turn their attention to the rejections of the claims under 35 U.S.C. § 102(e) and 35 U.S.C. § 103(a) set forth in the outstanding Office action. More specifically, claims 37-49, 53, 56-61, 72-74 and 83 were rejected under § 102(e) as being anticipated by Robinson et al. (U.S. Patent No. 5,891,193) and claims 54, 62-71, 75, 76, 84 and 85 were rejected under § 102(e) in view of Robinson et al. or in the alternative under § 103(a) in view of Robinson et al. Moreover, claims 51 and 52 were rejected under § 103(a) as being unpatentable over Robinson et al. in view of Hillstead (U.S. 4,856,516) or Tower (U.S. 5,217,483).

Accordingly, it is to be noted that as an initial matter, in view of the Terminal Disclaimer filed concurrently herewith, claims 50, 55 and 77-82 are now believed to be allowable since the claims are not rejected in view of the art.

Further, it is respectfully submitted that the Robinson et al. patent does not disclose the subject matter recited in the claims and as such, claims 37-49, 51-54, 56-76 and 83-85 are not anticipated or rendered obvious by the teachings of Robinson et al.

Notably, in rejecting claims 37-49, 53, 56-61, 72-74 and 83 under § 102(e), the Examiner states that since the stent disclosed in Robinson et al. can be bent to form the stent, the stent is therefore plastically deformable and can be expanded to a state where there would be no bends in the wires forming the stent. The Examiner then concluded that "this unbent expanded diameter reads on the 'diameter suitable to hold open the coronary artery' as claimed." The Examiner then further stated that "self-expansion depends on how the device is used and how it is biased." However, there is no recognition in the cited Robinson et al. patent of using or biasing the disclosed stent in a manner other than for self-expansion and as such, the Robinson et al. patent does not teach each and every limitation recited in the claims as is required under § 102(e). Clearly, the Robinson et al. patent does not teach the balloon expandable stent recited in independent claims 37, 44, 53 and 83 or their respective dependent claims. Further, the Robinson et al. reference does not teach a stent including cylindrical elements which can not be elastically compressed to a first low profile delivery configuration without plastic deformation or which have an elasticity insufficient to allow expansion from the first low profile delivery configuration to a second radially expanded configuration without plastic deformation as recited in claims 37-44 and 72-76. Moreover, Robinson et al. does not teach a stent having a first low profile configuration for delivery and a second radially expanded configuration and which is plastically deformable from the first low profile

configuration to the second radially expanded configuration as is recited in claims 44-50 nor cylindrical elements of a stent having an elasticity insufficient to allow expansion from a first low profile configuration to a second radially expanded configuration without permanent plastic deformation as is recited in claim 53-61 and 83. In fact, the Robinson et al. patent teaches a self-expanding anchor which is "compressible to a low profile (small diameter) and can expand resiliently to an enlarged diameter" (See Summary of the Invention; Col. 3, lns. 4-6). Since the Robinson et al. patent does not teach the above-identified subject matter, it does not constitute anticipatory art. Therefore, it is respectfully submitted that claims 37-50, 53-61, 72-76 and 83 are allowable over the cited Robinson et al. patent.

For similar reasons, it is believed that the rejections of claims 54, 62-71, 75, 76, 84 and 85 under 102(e) or in the alternative under 103(a), is traversed. Notably, the allowability of dependent claims 54, 75 and 76 have been addressed above as these claims have been shown to be allowable due to the significant distinctions between the subject matter recited in their respective independent claims, namely claims 53 and 37, and the Robinson et al. patent. Claims 62-71, 84 and 85 are believed to also recite subject matter which clearly distinguishes these claims for the Robinson et al. patent. That is, each of claims 62-71, 84 and 85 recite a stent that is plastically deformable from a low profile delivery configuration to a radially expanded configuration. As stated, the Robinson et al. patent simply does not contemplate plastically deforming a stent from a low profile delivery configuration to an expanded configuration. Robinson et al. also does not contemplate a balloon expandable stent as is required by claims 84 and 85.

Without any recognition of the same, it is respectfully submitted that Robinson et al. neither anticipates nor renders obvious the subject matter of claim 54, 62-71, 75, 76, 84 and 85.

It is also respectfully submitted that claims 51 and 52 are allowable over the combination of the Robinson et al. patent and the Hillstead or Tower patents. Again, the Robinson et al. patent is completely lacking in the teaching of a balloon expandable stent as well as cylindrical elements having an elasticity insufficient to allow expansion from a first low profile delivery configuration to a second radially expanded configuration without permanent plastic deformation as is recited in independent claim 51. Moreover, neither Robinson et al. nor the other cited art teach the balloon expandable stent including an interior chamber configured to receive an expandable member for plastically expanding the stent, the stent formed of an alloy containing cobalt, chromium, molybdenum and nickel, as is recited in claim 52. Therefore, Applicants respectfully traverse the 103(a) rejection of the claims 51 and 52. Accordingly, it is respectfully submitted that claims 51 and 52 are also allowable over the cited art.

CONCLUSION

Applicants have attempted to completely respond to the rejections set forth in the outstanding Office action. In view of the above amendments and remarks, Applicant respectfully request that the application be reconsidered, the claims allowed and the application passed to issue.

Respectfully submitted,
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Heat Treatment of Steel

From the 1924 edition of Machinery's Handbook
This is section 3 of 7

Two of the illustrations have been traced in SuperPaint and the rest are as scanned. They looked better in the book.

DISCLAIMER: DON'T WRITE FOR ADVICE ON THIS STUFF. I DON'T HAVE ANY.
Detailed table of contents
First section: Furnaces and Baths for Heating Steel
Previous section: Pyrometers
Next section: Tempering

Hardening

Critical Temperatures. -- The "critical points" of carbon tool steel are the temperatures at which certain changes in the chemical composition of the steel take place, during both heating and cooling. Steel at normal temperatures has its carbon (which is the chief hardening element) in a certain form called *pearlite* carbon, and if the steel is heated to a certain temperature, a change occurs and the pearlite becomes *martensite* or hardening carbon. If the steel is allowed to cool slowly, the hardening carbon changes back to pearlite. The points at which these changes occur are the decalescence and recalescence or critical points, and the effect of these molecular changes is as follows: When a piece of steel is heated to a certain point, it continues to absorb heat without appreciably rising in temperature, although its immediate surroundings may be hotter than the steel. This is the *decalescence* point. Similarly, steel cooling slowly from a high heat will, at a certain temperature, actually increase in temperature, although its surroundings may be colder. This takes place at the *recalescence* point. The recalescence point is lower than the decalescence point by anywhere from 85 to 215 degrees F., and the lower of these points does not manifest itself unless the higher one has first been fully passed. These critical points have a direct relation to the hardening of steel. Unless a temperature sufficient to reach the decalescence point is obtained, so that the pearlite carbon is changed into a hardening carbon, no hardening action can take place; and unless the steel is cooled suddenly before it reaches the recalescence point, thus preventing the changing back again from hardening to pearlite carbon, no hardening can take place. The critical points vary for different kinds of steel and must be determined by tests in each case. It is the variation in the critical points that makes it necessary to heat different steels to different temperatures when hardening.

Determining Hardening Temperatures. -- The temperatures at which decalescence occurs vary with the amount of carbon in the steel, and are also higher for high-speed steel than for ordinary crucible steel. The decalescence point of any steel marks the correct hardening temperature, and the steel should be removed from the source of heat as soon as is has been heated uniformly to this temperature. Heating the piece slightly above this point may be desirable, either to insure the structural change being complete throughout, or to allow for any slight loss of heat which may occur in transferring the work from the furnace to the quenching bath. When steel is heated above the temperature of decalescence, it is non-magnetic. If steel is heated to a bright red, it will have no attraction for a magnet or magnetic needle, but at about a "cherry-red," it regains its magnetic property. This phenomenon is sometimes taken advantage of for determining the correct hardening temperature, and the use of a magnet is to be recommended if a pyrometer is not available. The only point requiring judgment is the length of time the steel should

remain in the furnace after it has become non-magnetic, as the time varies with the size of the piece. When applying the magnetic needle test, be sure that the needle is not being attracted by the tongs.

The correct hardening temperature for any carbon steel can be determined accurately by the use of a pyrometer. A form of apparatus often used for testing specimens of steel consists of a small electric furnace in which to heat the specimen, and a special thermo-couple pyrometer (see "Pyrometers") for indicating the range of temperatures through which the steel passes. The pyrometer consists of a thermo-couple, connecting leads and an indicating meter. The thermo-couple is of small wire so as to respond readily to any slight temperature variation. When testing a piece of steel with this apparatus, the temperature indicated by the meter rises uniformly until the decalescence point is reached. At this temperature, the indicating pointer of the meter remains stationary, the added heat being consumed by internal changes. When these changes are completed, the temperature again rises, the length of the elapsed period depending upon the speed of heating. The temperature at which this pause in the motion of the indicating pointer occurs should be carefully noted. To obtain the lower critical point, the temperature is first raised about 100 degrees F. above the decalescence point; the steel is then removed from the furnace and is allowed to cool. The decrease of temperature is immediately shown by the fall of the meter pointer, and, at a temperature somewhat below the decalescence point, there is again a noticeable lag in the movement of the pointer. The temperature at which the movement ceases entirely is the recalescence point. Immediately following, there may occur a slight rising movement of the pointer. During these intervals of temperature lag, both during heating and cooling, there may occur a small fluctuation in temperature; hence, a definite point in each of these intervals should be considered when a test is made, both critical temperatures being taken at the time the pointer first becomes stationary.

While it is possible to harden steel within a temperature range of about 200 degrees and obtain what might seem to be good results, the best results are obtained within a very narrow range of temperatures which are close to the decalescence point. The hardening temperature for both low tungsten and carbon steel can be located with accuracy, and the complete change from soft to hard occurs within a range of 10 degrees F. or less. After the temperature has been increased more than from 35 to 55 degrees F. above the hardening point, the hardness of steel is lessened by a higher temperature, provided the heating is sufficiently prolonged for the steel to be thoroughly heated.

Hardening or Quenching Baths. -- When steel heated above the critical point is plunged into a cooling bath, the rapidity with which the heat is absorbed by the bath affects the degree of hardness; hence, baths of various kinds are used for different classes of work. Clear cold water is commonly employed and brine is sometimes substituted to increase the degree of hardness. Sperm [whale oil] and lard oil baths are used for hardening springs, and raw linseed oil is excellent for cutters and other small tools. The effect of a bath upon steel depends upon its composition, temperature, and volume. The bath should be amply large to dissipate the heat rapidly, and the temperature should be kept about constant, so that successive pieces will be cooled at the same rate. Greater hardness is obtained from quenching in salt brine, and less in oil, than is obtained by the use of water. This is due to the difference in the heat-dissipating qualities of these substances. When water is used, it should be "soft," as unsatisfactory results will be obtained with "hard" water. If thin pieces are plunged into brine, there is danger of cracking, owing to the suddenness of the cooling.

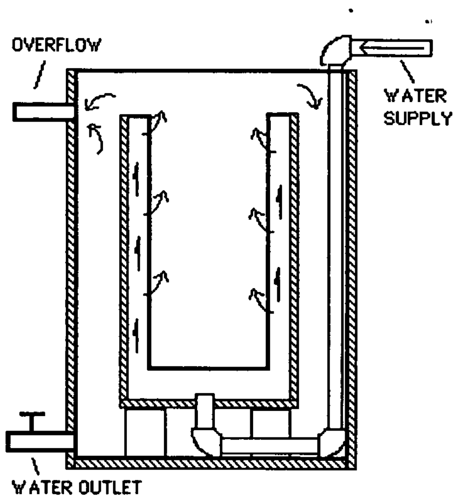
The temperature of the hardening bath has a great deal to do with the hardness obtained. In certain experiments a bar quenched at 41 degrees F. showed a scleroscopic hardness of 101. A piece from the same bar quenched at 75 degrees F. had a hardness of 96, while, when the temperature of the water was raised to 124 degrees F., the bar was decidedly soft, having a hardness of only 83. The higher the temperature of the quenching water, the more nearly does its effect approach that of oil, and if boiling water is used for quenching, it will have an effect even more gentle than that of oil; in fact, it would leave the steel nearly soft. With oil baths, the temperature changes have little effect on the degree of

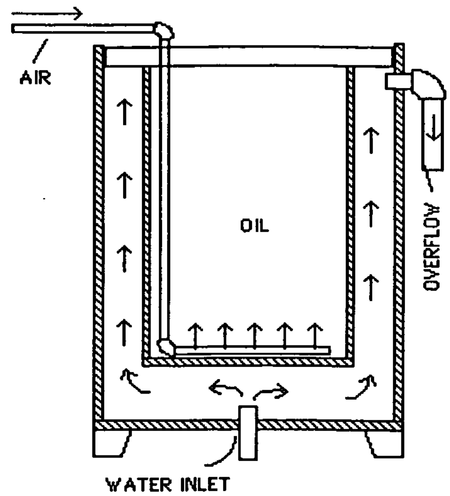
hardness. Parts of irregular shape are sometimes quenched in a water bath that has been warmed somewhat to prevent sudden cooling and cracking. A water bath having one or two inches of oil on top is sometimes employed to advantage for tools made of high-carbon steel, as the oil through which the work first passes reduces the sudden action of the water.

Irregularly shaped parts should be immersed so that the heaviest of thickest section enters the bath first. After immersion, the part to be hardened should be agitated in the bath; the agitation reduces the tendency of the formation of a vapor coating on certain surfaces, and a more uniform rate of cooling is obtained. The work should never be dropped to the bottom of the bath until quite cool. High-speed steel is cooled for hardening either by means of an air blast or an oil bath. Both fresh and salt water are also used, although, as a general rule, water should not be used for high-speed steel. Various oils, such as cotton-seed, linseed, lard, whale oil, kerosene, etc., are also employed; many prefer cotton-seed oil. Linseed has the objection of becoming gummy, and lard oil has a tendency to become rancid. Whale oil or fish oil give satisfactory results, but have offensive odors, although this can be overcome by the addition of about three per cent of heavy "tempering" oil.

A quenching solution of a 3 per cent sulphuric acid and 97 per cent of water will make hardened carbon steel tools come out of the quenching bath bright and clean. This bath is sometimes used for drills and reamers which are not to be polished in the flutes after hardening. Another method of cleaning drills and similar tools after hardening is to pickle them in a solution of 1 part hydrochloric acid and 9 parts water. Still another method is to use a heating bath consisting of 2 parts barium chloride and 3 parts potassium chloride. This method is satisfactory for reamers and tools which are not to be polished in the flutes after hardening.

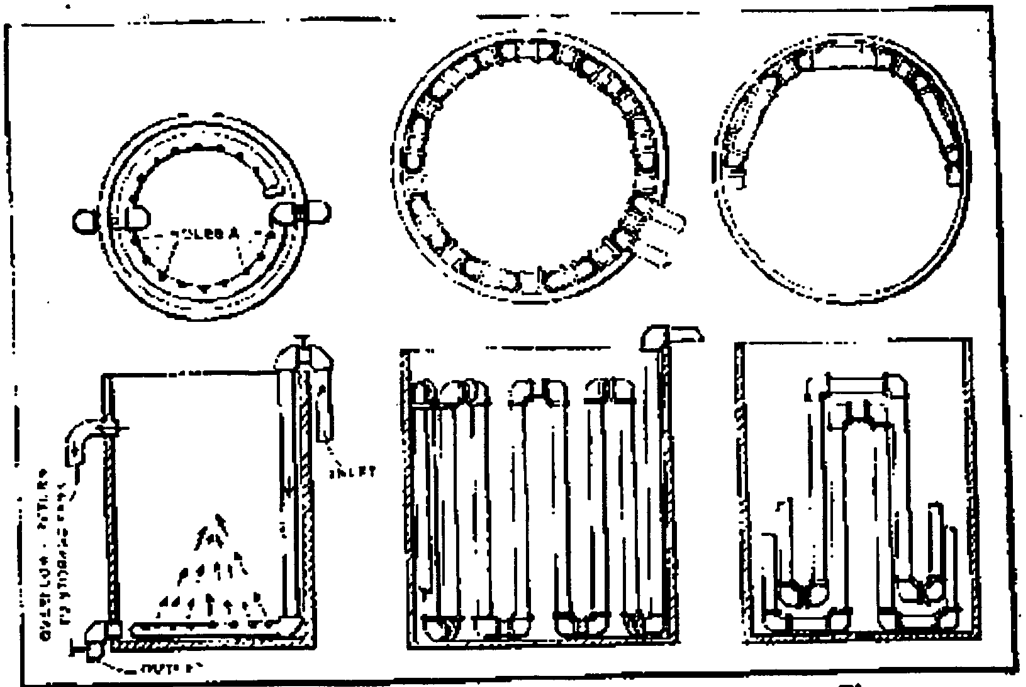
Oil Quenching Baths. -- Oil is used very extensively as a quenching medium as it gives the best proportion between hardness, toughness and warpage for standard steels. Special compounded oils of the soluble type are now used in many plants instead of such oils as fish oil, linseed oil, cotton-seed oil, etc. The soluble properties enable the oil to make an emulsion with water. A good quenching oil should possess a flash and fire point sufficiently high to be safe under the conditions used and 350 degrees F. should be about the minimum point. The specific heat of the oil regulates the hardness and toughness of the quenched steel, and the greater the specific heat, the harder the steel will be. Specific heats of quenching oils vary from 0.20 to 0.75, the specific heats of fish, animal, and vegetable oils usually being from 0.2 to 0.4, and of soluble and mineral oils, from 0.5 to 0.7. The oil should not contain water, gum when used, have a disagreeable odor or become rancid. A great many concerns use paraffin and mineral oils for quenching, while a few use crude fuel oils. The quantity of steel that can be quenched per gallon of oil depends on the fluidity of the oil, or its draining qualities. The so-called "refrigerating qualities" are really the capacity of the oil to remove the heat from the steel at a fast rate and then radiate its own heat to the atmosphere.





Tanks for Quenching Baths. -- The main point to be considered in a quenching bath is to keep it at a uniform temperature, so that each successive piece quenched will be subjected to the same heat. The next consideration is to keep the bath agitated, so that it will not be of different temperatures in different places; if thoroughly agitated and kept in motion, as is the case with the bath shown in Fig. 1, it is not even necessary to keep the pieces in motion in the bath, as steam will not be likely to form around the pieces quenched. Experience has proved that if a piece is held still in a thoroughly agitated bath, it will come out much straighter than if it has been moved around in an unagitated bath. This is an important consideration, especially when hardening long pieces. It is, besides, no easy matter to keep heavy and long pieces in motion unless it be done by mechanical means.

In Fig. 1 is shown a water or brine tank for quenching baths. Water is forced by a pump or other means through the supply tube into the intermediate space between the outer and inner tank. From the intermediate space it is forced into the inner tank through holes as indicated. The water returns to the storage tank by overflowing from the inner tank into the outer one and then through the overflow pipe as indicated. In Fig. 3 is shown another water or brine tank of a more common type. In this case the water or brine is pumped from the storage tank and continuously returned to it. If the storage tank contains a large volume of water, there is no need of a special means for cooling. Otherwise, arrangements must be made for cooling the water after it has passed through the tank. The bath is agitated by the force with which the water is pumped into it. The holes at *A* are drilled at an angle, so as to throw the water toward the center of the tank. In Fig. 2 is shown an oil quenching tank in which water is circulated in an outer surrounding tank for keeping the oil bath cool. Air is forced into the oil bath to keep it agitated. Fig. 6 shows a water and oil tank combined. The oil is kept cool by a coil passing through it in which water is circulated, which later passes into the water tank. The water and oil baths in this case are not agitated.



Illustrations: Fig. 3-4-5 Fig. 3 Fig. 4 Fig. 5

Fig. 4 shows the ordinary type of quenching tank cooled by water forced through a coil of pipe. This can be used for either oil, water or brine. Fig. 5 shows a similar type of quenching tank, but with two coils of pipe. Water flows through one of these and steam through the other. By this means it is possible to keep the bath at a constant temperature.

Hardening High-speed Steel. -- High-speed steel must be heated to a much higher temperature than carbon steel. A temperature of from 1400 degrees to 1600 degrees F. is sufficient for carbon steel; high-speed steel requires from 1800 degrees to 2200 degrees F. The usual method of hardening a high-speed steel tool, such as a turning or planing tool, is to heat the cutting end slowly to a temperature of about 1800 degrees F., and then more rapidly to about 2200 degrees F., or until the end is at a dazzling white heat and shows signs of melting down. The tool point is then cooled either by plunging it in a bath of oil (such as linseed or cotton-seed) or by placing the end in a blast of dry air. When an oil quenching bath is used, its temperature is varied from the room temperature to 350 degrees F., according to the steel used. The exact treatment varies for different steels and it is advisable to follow the directions given by the steel makers. High-speed steel parts that would be injured by a temperature high enough to melt the edges are hardened by heating slowly to as high a degree as possible and then cooling, as described. Formerly, the air blast was recommended by most steel makers, but oil is now extensively used. Care should be taken to quench the heated steel rapidly after removing from the source of heat. The barium-chloride bath has been used quite extensively for heating machine-finished, high-speed steel tools preparatory to hardening. The barium-chloride forms a thin coating on the steel, which is thus protected from oxidation while being transferred from the heating bath to the cooling bath. Tests have demonstrated, however, that barium-chloride baths have certain disadvantages for heating high-speed steel preparatory to hardening, because if the steel is heated to the required temperature, the surface of the tool is softened to some extent. These tests indicate that whenever this salt is used as a heating bath, the temperature should not be raised above 2050 degrees F. When about 0.010 inch is ground from the cutting edges of the tools, the influence of heating in barium chloride may be negligible. (See "Disadvantages of Barium-chloride Bath".)

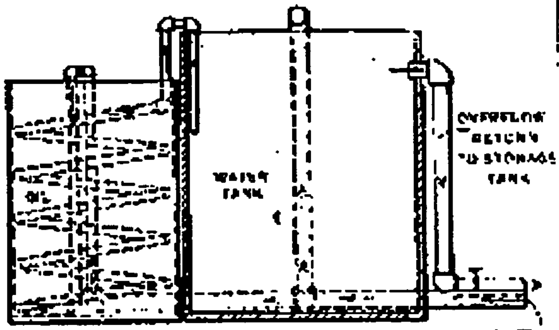
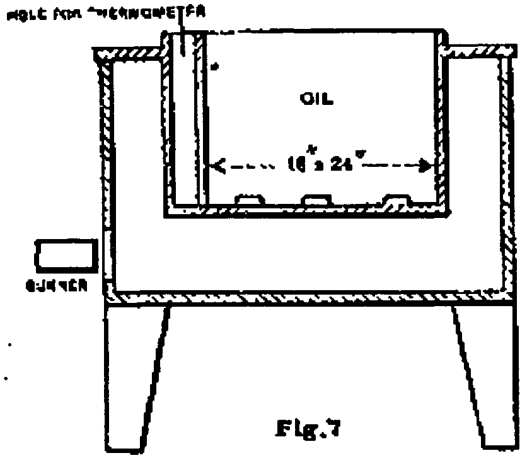
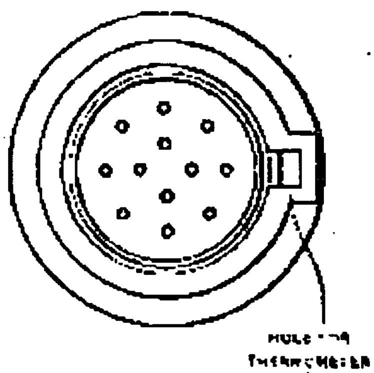
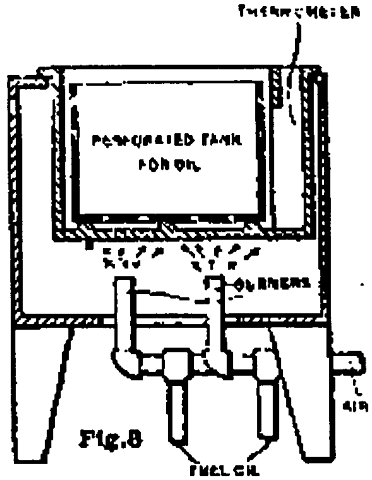


Fig.6







Very satisfactory results in hardening high-speed steel tools, such as cutters, drills, etc., have been obtained by the following method: First pre-heat in an oven-type gas furnace to from 1300 degrees to 1500 degrees F.; then transfer the steel to another gas furnace having a temperature varying from about 2000 degrees to 2200 degrees F.; when the steel has attained this temperature, quench in a metallic salt bath having a temperature varying from 600 degrees to 1200 degrees F., depending on the kind of high-speed steel used. The piece to be hardened should be stirred vigorously in the bath until it has obtained the temperature of the bath; then it is cooled, preferably in the air, and requires no further tempering; or it may be put directly into the tempering oil, which should be at a temperature anywhere between 100 and 600 degrees F. The tempering bath is then gradually raised to the heat required for tempering. The salt bath used for quenching should be calcium chloride, sodium chloride and potassium ferro-cyanide, in proportions depending upon the required heat. Various kinds of steel require different temperatures for the metallic salt bath. After the temper of the tool has been drawn in the oil, the work is dipped in a tank of caustic soda, and then in hot water. This will remove all oil which might adhere to the tools, and

	1425	1050	0.997	180,700	28,070,000	0.04850	
	1425	900	0.998	233,900	28,860,000	0.04870	
	1425	750	0.994	240,800	29,220,000	0.04790	0.744
	1425	600	0.991	219,800	30,420,000	0.04736	0.175
	1425	not drawn	0.991	219,800	29,960,000	0.04730	0.175
Annealed in Lead at 1400 deg. F.			0.991	78,500	27,550,000	0.04730	

Local Hardening. -- One method of hardening locally is to cover the part that is to remain soft with a thin metal shield, so that it prevents the surface from being suddenly cooled by the direct action of the cooling medium. The steam or vapor which forms beneath the cover prevents the cooling medium from entering until the work has cooled sufficiently to prevent hardening; hence, a rather loose-fitting shield is desirable. The shield should be made of sheet iron or steel of about No. 29 gage (0.014 inch), for ordinary work. It is composed of one or more pieces, depending on the shape of the part, and, when several pieces are required, they can be bound together with wires or rivets. Of course, the surfaces to be hardened are left exposed. The heating should be done in a furnace or open-forge fire. A lead bath should not be used, because the hot lead beneath the shield will cause an explosion when the part is cooled. The quenching bath can be the same as when the shield is not used.

Local hardening is also effected by the application of a compound called "Enamelite" to the parts which are to remain soft. This compound, for tool steel, is in the form of a powder which is mixed with hot water to form a paste. It has the property of clinging to the steel and liberating hydrogen (the greatest known non-conductor) when the heated steel is plunged into the water. This causes the steel to retain its heat long enough to escape the chill, so that it remains soft where the enamelite has been applied.

Defects in Hardening. -- Uneven heating is the cause of most of the defects in hardening. Cracks of a circular form, from the corners or edges of a tool, indicate uneven heating in hardening. Cracks of a vertical nature and dark-colored fissures indicate that the steel has been burned and should be put on the scrap heap. Tools which have hard and soft places have been either unevenly heated, unevenly cooled, or "soaked", a term used to indicate prolonged heating. A tool not thoroughly moved about in the hardening fluid will show hard and soft places, and have a tendency to crack. Tools which are hardened simply by dropping them to the bottom of the tank, sometimes have soft places, owing to contact with the floor or sides of the tank. They should be thoroughly quenched before dropping. when a tool appears soft and will not harden, it probably has been decarbonized on the surface by too much heat or by soaking too long. The surface must be removed before the tool will harden properly. Tools are sometimes soft because the cooling bath is not large enough for the tools being hardened, and becomes too warm after a few pieces have been quenched.

Overheated Steel. -- Overheated steel that is not actually burned can be partly restored by heating to the proper heat, and allowing it to cool slowly in hot ashes or sand; when cold, the steel is hardened again at the proper hardening heat. Tools treated in this way are not as good as when treated at the proper heat throughout, but they are partially restored, and if the overheating originally took place in forging, the risk of cracking in hardening will be lessened by adopting the process mentioned. Care should be taken that the tuyere of the forge is well covered when heating tool steel; a tool coming in direct contact with the air blast will become surface burned, show soft places in hardening and wear badly in use.

Scale on Hardened Steel. -- The formation of scale on the surface of hardened steel is due to the contact of oxygen with the heated steel; hence, to prevent scale, the heated steel must not be exposed to the action of the air. When using an oven heating furnace, the flame should be so regulated that it is not

visible in the heating chamber. The heated steel should be exposed to the air as little as possible, when transferring it from the furnace to the quenching bath. An old method of preventing scale and retaining a fine finish on dies is as follows: Fill the die impression with powdered boracic acid and place near the fire until the acid melts; then add a little more acid to insure covering all the surfaces. The die is then hardened in the usual way. If the boracic acid does not come entirely off in the quenching bath, immerse the work in boiling water. Dies hardened by this method are said to be as durable as those heated without the acid. Detailed table of contents
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